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Research and Development

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Project Summary

Forest Health Monitoring 1991 Statistical Summary

The interagency Forest Health Monitoring program has been implemented in 12 eastern states. The full report is the first comprehensive statistical report by the program. It provides statistical summaries of tree health and forest condition measurements that were made at 628 field locations in 1991. Based on an analysis of selected measurements of tree crown condition, tree crowns appeared to be healthy for nearly all of the species and forest types that were sampled. The regional status of overstory tree species diversity and stand density is also summarized. Summaries of selected off-plot data describe climate, forest pests, and air pollution in the regions where the field measurements were made. Future reports will consider additional states and more measurements as they become available.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background

In response to the diverse and growing public concerns about potential human impacts on our environment, the U.S. Forest Service and the U.S Environmental Protection Agency (EPA) have initiated a cooperative national program of Forest Health Monitoring (FHM). Although not established in all parts of the nation, FHM has already provided valuable information about forest health in some areas. The objective is to provide a many-sided view of forest health that will assist the public and other decision makers in setting priorities and making informed choices aimed at reducing the ecological risks of human impacts.

The purposes of the full report are to describe the current approach and activities, to summarize the data that were collected in 1991, and to outline some new directions that are being explored for possible implementation later. The report is also a test of an assessment process by which data from many sources will be brought together for analyses. It is anticipated that suggestions received from the readers will enable FHM to tailor future reports to better meet the needs of information users. The appendices to the full report contain tables and charts so that readers may explore particular items of interest. A description of the statistical procedures used to prepare the report is also provided.

Procedures

There are now 925 plots in the FHM national network, of which 628 plots are forested. This is about 16% (excluding Alaska) of the projected total number of forested plots that will be installed nationwide over the next several years. The installed plots are located systematically, using a probability sampling design, throughout the forests of 12 states in the eastern U.S. During the late summer of 1991, these plots were visited by trained field crews to make selected measurements of forest health. Over 45,000 trees and seedlings of more than 100 species in 10 major forest types were measured by state and federal personnel. Through a rigorous quality assurance program, these data were found to meet data quality objectives. The data and supporting documentation have been entered into the FHM databases.

At each one-hectare forested plot location, four fixed-radius (7.32 meters) subplots were established. Within these subplots, forest condition measurements were made of tree size, species, frequency, damage, and crown condition. Additional measurements, such as slope

and aspect, were made to characterize the forested plot locations. Forest condition measurements were analyzed by using statistical procedures, and the results were expressed in tables, charts, and cumulative distribution functions. The cumulative distribution functions of the crown condition measurements were further analyzed to estimate the proportions of the sampled populations with different health status.

Data summaries and maps were also prepared for three types of off-plot data: climate, forest insects and diseases, and air pollution. For these off-plot data types, selected measurements that are made by other monitoring programs were summarized in a way that will permit future analyses of the possible determinants of forest health as indicated by the on-plot measurements. It was not possible to use the FHM statistical estimators for the off-plot data types; summary procedures that were appropriate for each particular off-plot database were used instead.

Results and Discussion—On-Plot Data

Although conclusions about regional forest health are tenuous when they are based on just a few measurements taken in just one year, the following general findings emerged from statistical analyses of the 1991 on-plot data:

Tree Size and Stand Density

Tree size and stand density measurements are important for many analyses of forest health and productivity. The full report summarizes stand density (expressed as basal area per unit area) and tree frequency (number of stems per unit area) for selected subpopulations that were measured in 1991. Results are presented in the form of cumulative distribution functions. These data will be the basis for assessments of tree and stand growth after the plots are remeasured in later years.

Tree Crown Conditions

Tree damage and crown condition were measured on all trees > 12.7 cm dbh on forested subplots. The full report presents summary tables and cumulative distribution functions of selected measurements, aggregated by species, forest type, and crown group. Subpopulations of species, forest types, and crown groups with a sufficient sample size were also delineated into categories of optimal, nominal, subnominal, and poor condition for selected measurements, based on expert judgment or published "threshold" values for those categories.

The measurement procedures are described in detail in the full report. Briefly, the following crown measurements were made:

Crown transparency
: A measure of the amount of sunlight that passes through foliated portions of a crown.

Crown dieback
: A measure of the mortality of relatively young branches that are in the upper, sunlight-exposed portions of the crown.

Crown position
: A measure of the relative physical location of a tree crown in a stand of trees.

Crown density
: A measure of the two-dimensional appearance of crown fullness and symmetry.

Crown ratio
: A measure of the amount of an entire tree bole that is foliated.

A Crown Defoliation Indicator (CDI) model was also used to describe overall crown condition as a function of the crown transparency and crown dieback measurements.

The interpretation of tree crown condition measurements depends not only on the ecological significance of a particular measured value, but also on the perceived importances of relatively high or relatively low values. The approach taken here to setting the threshold values of condition was conservative. Where possible, the setting of threshold values considered expected differences among species, size classes, crown positions, and typical habitat characteristics.

A cursory evaluation of the cumulative distribution function analysis results indicated that most of the tree species, all examined forest types, and most crown groups examined were in good condition. It was recognized that since most of the population for species and crown groups were found to be nominal, the thresholds might be too high. If this is true, then the percentages of the population that were in a subnominal condition should be of greater concern.

Research both off the detection monitoring plots and using data from the detection monitoring plots is needed to set consistent and tailored threshold values for each species, forest type, and/or crown group.

Tree Species Diversity

The full report quantifies the tree species diversity of the overstory community by using three well known diversity indices—the number of species present, the natural exponent of Shannon's index, and the reciprocal of Simpson's index. Data for trees > 12.7 cm diameter at breast height were used to calculate the diversity indices. Cumulative distribution functions of the indices were used to quantify the 1991 regional status of overstory tree species diversity in the northeast and southeast U.S.

The cumulative distribution functions of the diversity indices were not significantly different within either geographic region. Using the exponent of Shannon's index to illustrate the results for the northeast region, cumulative probability values of 0.25, 0.50, and 0.75 were obtained when the index was 2.2, 3.6, and 4.6, respectively. The corresponding index values for the southeast region were 1.6, 2.9, and 4.6, respectively.

Although statistical relationships do not imply cause and effect, some associations were explored among forest characteristics and the values of the exponent of Shannon's index. In the southeast region, high overstory tree species diversity values were most closely associated with an oak forest type, natural stand origin, saw timber size class, no recent disturbances, and more than one plot condition code. In contrast, low values were most closely associated with a pine forest type, planted stand origin, seedling/sapling size class, recent cutting disturbance, and one plot condition code. Interpretations of these statistical associations were difficult because of confounding or correlations among the forest characteristics.

In the northeast region, the possible associations of diversity values and forest characteristics were even more difficult to investigate because there was relatively little variation in forest characteristics. For example, the northern hardwoods forest type had sample plots distributed over the full range of diversity index values, but stand origins and size classes were the same for most of those plots. Although few pine plots were sampled in the northeast, their proportion decreased as diversity values increased. In contrast to the southeast region, recent disturbances were not associated with diversity values in the northeast region.

The cumulative distribution functions of the two geographic regions were most different at lower diversity values. The difference was not statistically significant and was explainable by higher proportions of the pine forest type and planted stand origin in the southeast in comparison to the northeast. The number of species was more sensitive than the exponent of Shannon's index to regional differences.

Results and Discussion—Off-Plot Data

Three types of off-plot information were introduced into the FHM databases in 1991. Data from the Forest Service (forest insects and diseases), EPA (ozone and wet deposition), and the National Oceanic and Atmospheric Administration (precipitation, temperature, and significant weather events) were summarized by FHM analysts. In future reports, these and other summaries will be used to explore possible regional associations between on-plot measurements and particular stresses that are of concern. The highlights of the auxiliary data summaries follow:

Major Forest Insects and Diseases (Eastern U.S.)

A compilation of information from various state and federal sources identified four problems of special interest. A new disease (cause unknown) of blackgum has been found in the Appalachian Mountains in three states. Thousands of cabbage palms have died from unknown causes along the Florida Gulf coast. Populations of the black twig borer (an introduced ambrosia borer) are increasing and affecting a large number of tree species. Dogwood anthracnose, first discovered in 1987, is expanding rapidly throughout the range of flowering dogwood.

The report summarizes the status of a large number of common forest insects and diseases. Detailed insect information is provided for the hemlock wooly adelgid, the hemlock loopers, the eastern spruce budworm, the southern pine beetle, and the gypsy moth. Detailed information is also provided for fusiform rust, the littleleaf disease syndrome, the oak decline syndrome, and the beech bark disease. Observations of other insects and diseases are organized according to forest types. Evidence of damage from weather events and ozone is mentioned.

Climate

The climate report summarizes selected climate conditions and events that are known from experience to affect forest health. Data from a variety of sources were summarized into databases and maps of precipitation, hurricane occurrence, high wind events, ice storms, and late spring hard freezes. The period from October 1990 through September 1991 is summarized for the regions where FHM plots were measured in 1991.

Highlights include severe tropical storms in the fall, a record warm winter with low snowfall, an early spring, a severe spring ice storm, and a long and hot summer punctuated by Hurricane Bob.

Air Pollution

Maps of interpolated ozone data for low elevations in the eastern U.S. and maps and regional summary statistics for selected ions in precipitation revealed the general trends described below. Emissions data, dry deposition, and pollutants that are typically point source-oriented were not included in the full report.

A summary of ozone data for the years 1985-1989 was made using the seasonal (April through October) “W126 index” that places an emphasis on peak ozone hourly average concentrations. In general, ozone concentrations vary among years, but over the five-year period there were two regions that tended to give higher values of the W126 index. One region extends continuously along the mid-Atlantic seacoast and west to the Appalachian Mountains. The second region is smaller and is centered over the Ohio River valley near the Ohio-Indiana border. Ozone data sources included the EPA Aerometric Information Retrieval System, the National Dry Deposition Network, and the Mountain Cloud Chemistry Program.

Data from the National Atmospheric Deposition Program were used to prepare summaries of (precipitation-weighted) mean pH, sulfate deposition, nitrate deposition, and ammonium deposition for 1990 (January through December). Precipitation was most acidic, and sulfate and nitrate deposition was highest, in a corridor that extended roughly from eastern Michigan and southern Indiana to New York and southern New England. Precipitation acidity and deposition of sulfate and nitrate generally decrease with distance away from this corridor. This general pattern is similar to that observed in earlier years. Nearly the entire eastern U.S. receives precipitation that is more acidic than “normal rainfall.” There was not a clear spatial pattern of ammonium deposition over the study area.

Conclusion

The full report describes the current approach and activities and summarizes the data that were collected in 1991. Looking to the future, FHM plans the following events and improvements by 1994:

- Agreements will be reached with additional state and federal agencies to increase the scope of FHM participation and to improve the efficiency of data collection and the depth of data analysis.
- The plot network will be expanded from 12 to 18-24 states, including states from the western and north-central regions of the nation.
- The core set of measurements made at each plot location will be expanded so that more aspects of forest condition can be monitored. New measurements must first pass a rigorous peer-review process, and candidates include measures of soil, wildlife habitat, and foliage chemistry.
- The collection of off-plot forest insect and disease information will be standardized.
- The set of off-plot databases will be augmented to include information from satellite sensors and soil surveys.
- The assessment capabilities will be developed further and made available to data analysts around the nation. Annual statistical summaries will be prepared, and the data will be made available for in-depth interpretive reports to address specific forest health issues.

Ralph Baumgardner *is the EPA Project Officer (see below).*
The complete report, entitled "Forest Health Monitoring 1991 Statistical Summary," (Order No. PB95-136172; Cost: $27.00, subject to change) will be available only from

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